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Determining fixed and operating costs of logging equipment

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DETERMINING FIXED AND OPERATING COSTS OF LOGGING EQUIPMENT

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During the past two decades, the declining supply of woods labor and rapidly increasing demand for, and cost of wood products have given impetus to the development of new logging equipment.

Today's logging equipment ranges anywhere from chain saws to complex multi-functional equipment which can fell, delimb, buck, and haul to the landing. To select specific equipment and use that equipment profitably, loggers should know something of equipment costs and how to determine them.

This paper analyzes equipment costs and gives a procedure for estimating them. It is intended for those who are in the logging business and need a standardized guide to help them appraise the efficiency and production costs of logging equipment. It can also be used as a basic teaching aid for forestry students.

PRELIMINARY DATA AND DEFINITIONS

Total equipment costs include all costs accrued from buying, owning, and operating equipment. For analysis, equipment costs can be grouped into **fixed costs, operating costs,** and **labor costs.** To calculate these costs, the user needs preliminary information and understanding of the following definitions.

Equipment Specifications

Model, type of equipment, net horsepower at flywheel, capacity of crankcase, and hours between oil changes, are necessary to calculate the cost of equipment per unit of time. They can be obtained from either the equipment specification sheet, the owner's manual, or both.

Initial Investment (P)

This is defined as the actual equipment purchase cost, less the tire cost, regardless of whether the equipment is purchased at full price or discounted rates.

The initial investment includes the following sub-categories:

- Equipment costs with standard attachment
- Optional attachment cost
- Sales taxes (State and local)
- Freight cost
- Miscellaneous

Freight costs are usually given in terms of F.O.B. free-on-board price. F.O.B. price simply means that at the given location the buyer takes title to the equipment and is responsible for shipment if necessary. The most common pricing policies are F.O.B. factory and F.O.B. delivered price (Ballau 1973):

- F.O.B. factory price—the buyer takes title to the equipment at the factory and is responsible for shipment.
- F.O.B. delivered price—the equipment is priced at a specific delivery point. The price includes freight, packing, insurance, etc., and the buyer takes title of the equipment at this point.

Miscellaneous costs, such as for installation or adaptation of the equipment to the logging system, should be included in the initial investment cost.

Salvage Value (S)

This is defined as the amount that equipment can be sold for at the time of its disposal. The actual salvage value of equipment is affected by current market demand for used equipment and the condition of the equipment at the time of disposal. However, estimating the future salvage value of equipment is very difficult because it is based on the future market value and the unknown condition of the equipment at the time of its disposal. The estimates come from owners themselves or from manufacturers or dealers. As a rule of thumb, the salvage value can be considered 20 percent of the initial investment cost.

Economic Life (N)

This is the period over which the equipment can operate at an acceptable operating cost and productivity. The economic life is generally measured in terms of years, hours, or mileages (trucks and trailers). It depends on two factors—physical and functional impairment.

Physical impairment is caused by normal equipment deterioration due to such factors as corrosion, chemical decomposition, or by wear and tear due to abrasion, shock, and impact. These may result from normal and proper usage, abusive and improper usage, age, inadequate or lack of maintenance, or severe environmental conditions. Functional impairment is when the equipment simply cannot meet the demand for expansion of operation and change of harvesting system or becomes economically or technologically obsolete.

The best indication of economic life of equipment is based on personal experience with similar equipment. According to Plummer,[1] ". . . equipment owners generally look at their 'down' time as a guide on when to trade. When the down time of a particular piece of equipment causes the entire logging system to lose time, they generally trade. Also, when the cost of lost production exceeds the cost of owning a new piece of equipment they trade". If such experience or a record is unavailable, the information can be obtained from manufacturers, trade organizations, or knowledgeable associations. The estimated life of certain types of equipment may be used to calculate the cost of equipment per unit of time as follows ([2,3]):

Equipment	*Years*
Chain saw-straight blade	1
Chain saw-bow blade	1
Big stick loader	5
Shortwood hydraulic loader	5
Longwood hydraulic loader	4
Uniloader	3
Front end loader	5
Skidder (cable)	3
Skidder (grapple)	3
Shortwood prehauler	4
Longwood prehauler	4
Feller-buncher	5
Chipper	5
Slasher	3

[1]*Personal communication from Mr. Glenn M. Plummer, Harvesting Development Manager, Georgia Kraft Company, Rome, GA.*

[2]*Under southern U.S. conditions.*

[3]*Source: Machine cost and rates table–handout at 1978 Timber Harvesting Short Course, LSU/MSU Logging and Forestry Operations Center, Bay St. Louis, MS.*

Scheduled Operating Time (SH)

Scheduled operating time is the time during which equipment is scheduled to do productive work (Rolston 1968). The time during which a machine is on standby is not considered scheduled operating time. If a machine is being replaced by a spare, the scheduled operating time of the replaced machine ends when the replacement arrives on the job. The scheduled operating time of the replacement begins when it starts to move toward the job. Scheduled operating time is determined as follows:

If a piece of equipment is scheduled for use 8 hours a day and the possible estimated working days (subtracting weekends, holidays, bad weather days, etc.), are 250, then:

SH = 8 hrs./day × 250 days/yr. = 2,000 hrs./yr.

Productive Time (H)

Productive time is that part of scheduled operating time during which a machine actually operates (Rolston 1968). Only rarely would scheduled operating time and productive time be equal for logging equipment due to delays such as mechanical breakdowns, personnel, weather, etc. Productive time (H) divided by scheduled operating time times 100 is termed percent machine utilization. To estimate the productive time of equipment use the following utilization percents ([2,3]):

Equipment	*Utilization* (Percent)
Chain saw-straight blade	50
Chain saw-bow blade	50
Big stick loader	90
Shortwood hydraulic loader	65
Longwood hydraulic loader	64
Uniloader	60
Front end loader	60
Cable skidder	67
Grapple skidder	67
Shortwood prehauler	64
Longwood prehauler	64
Feller-buncher	65
Chipper	75
Slasher	67

For example, suppose that a grapple skidder is scheduled for 2,000 operating hours per year. Then the estimated productive time per year is:

H = 2,000 hrs./yr. × 67% = 1,340 hrs./yr.

FIXED COSTS

Fixed costs do not vary with hours of operation. They are neither affected by the amount of equipment activity nor output and are incurred regardless of whether a piece of equipment is used or not. Fixed costs include **depreciation, interest, insurance,** and **taxes.**

Depreciation (D)

A piece of equipment loses its value with time and possesses only salvage value (or trade-in value) at the time of trade-in. The basic objective of the depreciation schedule is to recover the initial investment cost of equipment each year over its estimated economic life. The method for calculating depreciation is ordinarily determined by its planned or desired effect on profit and income taxes through the economic life of equipment. The three common methods generally used to compute depreciation are: (1) straight line, (2) declining balance, and (3) sum-of-the-year's-digits.

Straight line method

This assumes that the value of equipment decreases at a constant rate for each year of its economic life. The mathematical formula is:

$$D = \frac{P-S}{N}$$

Where: D = yearly depreciation charge
P = initial investment cost of equipment
S = salvage value
N = economic life in years

also, $DR = \frac{1}{N}$, where DR = depreciation rate per year.

Example 1.—Suppose a track-type feller-buncher costs $85,000 (F.O.B. delivered price). The economic life and salvage value are estimated as 5 years and $17,000, respectively. Then:

$$D = \frac{P-S}{N} = \frac{85{,}000-17{,}000}{5} = 13{,}600 \text{ per year}$$

$$DR = \frac{1}{N} = \frac{1}{5} = 0.20 \text{ or } 20 \text{ percent per year.}$$

The depreciation charge for each year and the undepreciated value at the end of each year are as follows:

Year	*Depreciation Charge*	*Undepreciated Value*
	(Dollars)	
0	—	85,000
1	13,600	71,400
2	13,600	57,800
3	13,600	44,200
4	13,600	30,600
5	13,600	17,000

Declining balance method

This assumes that a piece of equipment does not depreciate at a constant rate, but at a higher rate during the early years and less toward the end of its economic life. Tax laws allow that the equipment owner may use a depreciation rate 2, 1½, or 1¼ times as great as the rate of the straight-line method (U.S. Department of Treasury, IRS 1978). Thus, for income tax purposes, this method is favored by some who desire higher write-off rates during the early years of ownership and lesser rates in the later years.

Example 2.— If, in the preceding equipment example, a rate of twice the straight-line depreciation rate, or 40 percent is used, then the depreciation for the first year is:

$$\$85{,}000 \times .40 = \$34{,}000$$

and the value of equipment at the end of the first year is:

$$\$85{,}000 - \$34{,}000 = \$51{,}000$$

The depreciation value for the second year is calculated by applying the 40 percent rate to the value of equipment at the end of the first year, and so on over the estimated life of the equipment, using the following tabulation:

Year	*Depreciation Charge*	*Undepreciated Value*
	(Dollars)	
0	—	85,000
1	34,000	51,000
2	20,400	30,600
3	12,240	18,360
4	7,344	11,016
5	4,406	6,610

The $6,610 undepreciated value at the end of the fifth year is the estimated salvage value. If the estimated salvage value and the actual salvage value came to a different amount, this differential balance is usually written off when the equipment is traded in or disposed of.

Sum-of-the-year's-digits method

This method assumes that the value of equipment decreases at a decreasing fraction each year. This is achieved by applying a different fraction each year to the cost less its salvage value. The denominators of all the fractions are the same, that is, the sum of the numbers of years of estimated life. Thus, with a piece of equipment having an estimated economic life of 5 years, the denominator of fraction is 15 (the sum of 1 + 2 + 3 + 4 + 5). The numerator of the fractions is the number of years used in sequence, beginning with the number of the estimated economic life and decrease each year in consecutive order. Thus, the numerator for the first year is 5, for the 2nd, 3rd, 4th, and 5th years are 4, 3, 2, and 1, respectively. The numerator for each year is then divided by the common denominator. In this case, for example, the depreciation in the first year is 5/15 of the initial investment cost less salvage value, in the 2nd, 3rd, 4th, and 5th year are $^4/_{15}$, $^3/_{15}$, $^2/_{15}$, and $^1/_{15}$ of the initial investment cost less salvage value, respectively. To illustrate these, consider the following example.

Example 3.— Use the preceding equipment example again. The amount to be depreciated over its economic life is:

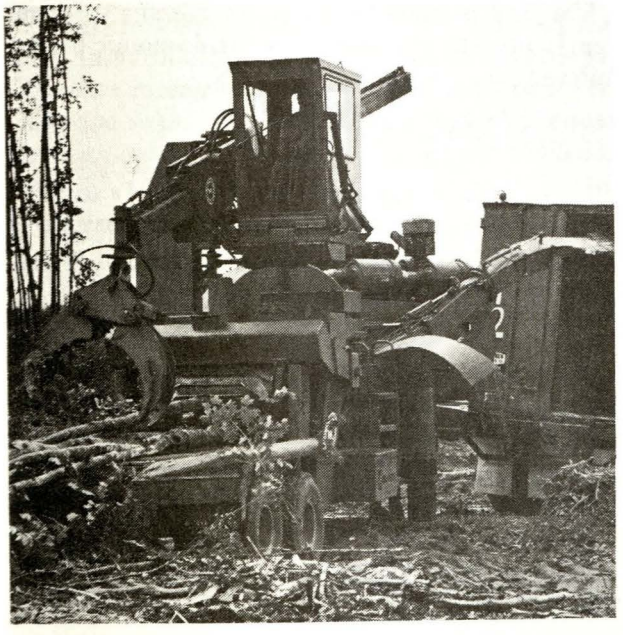
$$\$85{,}000 - \$17{,}000 = \$68{,}000$$

The denominator of fraction is:

$$1 + 2 + 3 + 4 + 5 = 15$$

The depreciation charge for the first year is:

$$\$68{,}000 \times {}^5/_{15} = \$22{,}667$$



The undepreciated value at the end of the first year is:

$$\$85{,}000 - \$22{,}667 = \$62{,}333$$

Proceeding in this manner, the yearly depreciation charge and the undepreciated value at the end of each year can be calculated using the following tabulation:

Year	*Depreciation Charge*	*Undepreciated Value*
	(Dollars)	
0	—	85,000
1	$68{,}000 \times {}^5/_{15} =$ 22,667	62,333
2	$68{,}000 \times {}^4/_{15} =$ 18,133	44,200
3	$68{,}000 \times {}^3/_{15} =$ 13,600	30,600
4	$68{,}000 \times {}^2/_{15} =$ 9,067	21,533
5	$68{,}000 \times {}^1/_{15} =$ 4,533	17,000

The three methods described above are best compared graphically (fig. 1). The declining balance and the sum-of-the-year's-digits methods have higher depreciation values during the early years, as compared with the straight-line method. These accelerated depreciation methods are generally used to maximize income tax savings in the early years of the economic life of equipment. On the other hand, the straight-line is not only the simplest method to calculate depreciation, but is generally the accepted method for estimating equipment cost per unit of time.

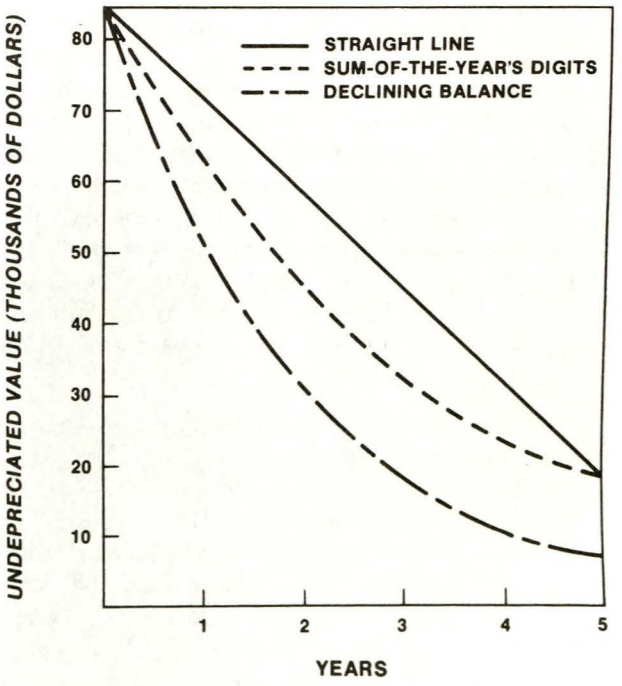


Figure 1.— *Graphical comparison of three methods.*

Interest, Insurance, and Taxes

Interest is the cost of using funds over a period of time. Investment funds may be borrowed or taken from savings or equity. If borrowed, the going interest rate is generally established by the lender. Interest rates may vary with locality and lending institution. If the money comes from personal savings or established equity, then an **opportunity cost,** or the rate this same money would earn if invested elsewhere (e.g., in U.S. savings bonds or a savings account), should be used as the interest rate. Twelve or 13 percent may be used as a rule of thumb for interest.

Every equipment owner must pay property or usage taxes on his equipment and should have one or more insurance policies for protection against damage, fire, and other destructive events. The cost of insurance and taxes also varies with locality and the type of equipment. Use the actual costs whenever they are available. If they are lacking, the Internal Revenue Service, the local court house, and insurance companies can provide some information concerning these costs. As a rule of thumb, 2 or 3 percent of the **average value of yearly investment** may be used for insurance, and 2 or 3 percent for taxes. The charges for interest, insurance, and taxes are generally applied to the average value of yearly investment. Two methods are usually used to calculate the average value of yearly investment (AVI).

The first method provides the average value of yearly investment over its entire economic life as follows:

$$AVI = \frac{(P-S)\,(N+1)}{2N} + S$$

Where: AVI = Average value of yearly investment over its entire economic life
P = Initial investment cost
S = Salvage value
N = Economic life in years.

Example 4.— Using the same equipment example, the charge for interest, insurance, and taxes are calculated as follows:

Data from Example 1 are:	
Initial investment (P)	$85,000
Economic life (N)	5 years
Salvage value (S)(20% of P)	$17,000

Then,

Table 1.— *Charge for interest, insurance, and taxes*
(In dollars)

Charges and Investments	Year 1	2	3	4	5
Investment-year's start	85,000	62,333	44,200	30,600	21,533
Depreciation charge	22,667	18,133	13,600	9,067	4,533
Investment—year's end	62,333	44,200	30,600	21,533	17,000
Average yearly investment	73,667	53,267	37,400	26,067	19,267
Charge for interest, insurance and taxes (assume 18 percent)	13,260	9,588	6,732	4,692	3,468

$$AVI = \frac{(85{,}000 - 17{,}000)\ (5+1)}{2(5)} + 17{,}000 = \$57{,}800$$

per year

Now, assume the interest, insurance, and tax rate as 12, 3, and 3 percent, respectively. Then, total percentage of interest, insurance and taxes is:

$$12\% + 3\% + 3\% = 18\%$$

The charge for interest, insurance, and taxes is:

Total % × AVI = 18% × \$57,800 = \$10,404 per year.

The advantage of this method is simplicity. This method is generally used for estimating equipment cost for comparison with other equipment, or with the production cost (dollars per unit of output) of alternative equipment. (This formula is usable only if the straight-line method is used to calculate the depreciation) (see Appendix A).

The second method provides the average value of yearly investment for each year (Church 1978). The value of equipment does not decrease continually from initial investment to salvage value but drops in increments at the end of each year. The average value of yearly investment (AVI) equals investment at the beginning of the year divided by two.

Example 5.— To illustrate, we use the data from the sum-of-the-year's-digits method of depreciation (see tabulation, right column, page 5) as follows:

Investment cost (P) at the beginning of the first year	\$85,000
Depreciation charge for the first year	\$22,667
Investment cost (P) at the end of the first year	\$62,333

Then,

$$AVI = \frac{85{,}000 + 62{,}333}{2} = \$73{,}667 \text{ for the first year}$$

The charge for interest, insurance, and taxes (assuming 18 percent total) is:

18% × \$73,667 = \$13,260 for the first year.

Similarly, the charges for interest, insurance, and taxes are calculated over the estimated equipment life (table 1).

One advantage of this method is that interest, insurance, and taxes can be calculated for each year regardless of the method of the depreciation; another is that equipment costs can be estimated for long periods and the replacement time determined.

OPERATING COSTS

Operating costs, unlike fixed costs, change in proportion to hours of operation or use (fig. 2). They depend on a host of factors, many of which are under control of the operator or the equipment owner to a certain extent.

Maintenance and Repair

These include everything from simple maintenance to the periodic overhaul of engine, transmission, clutch, brakes, and other major equipment components. Storage costs and preventive maintenance are also included. Operator use or abuse of equipment, the severity of working conditions, maintenance and repair policies, and the basic equipment design and quality, all affect maintenance and repair costs.

The cost of periodically overhauling major components may be estimated from the owner's manual and the local cost of parts and labor, or by getting advice from the manufacturer. Another owner's experience with similar equipment and cost records under typical working conditions are valuable sources. If experienced owners or cost records are not available, the hourly maintenance and repair cost can be estimated as a percentage of hourly depreciation cost, from the following tabulation (Warren 1977):

Machine	*Percentage rate*
Crawler tractor	[4]100
Agricultural wheel tractor	[4]100
Rubber tired skidder (cable)	[4]50
Rubber tired skidder (hydraulic grapple)	60
Loader(cable)	30
Loader (hydraulic)[5]	50
Chain saw (include maintenance)	100
Feller-buncher	50

To estimate hourly maintenance and repair cost, multiply the percent rate by the depreciation cost and divide its product by productive time per year.

Example 6.— Using data from example 5:

Initial investment (P)	$85,000
Economic life (N)	5 years
Salvage value (S)	$17,000

$$\text{Depreciation (straight-line method)} = \frac{85{,}000 - 17{,}000}{5} = \$13{,}600/\text{yr.}$$

[4]*Including winch.*

[5]*Knuckleboom (stationary).*

From the tabulation above, the percent rate for a feller-buncher is 50 percent. So, maintenance and repair costs = 50% × 13,600 = $6,800/yr.

Suppose the productive time has been established as 1,300 hours per year, then,

$6,800/year ÷ 1,300 hours/year = $5.23 per hour.

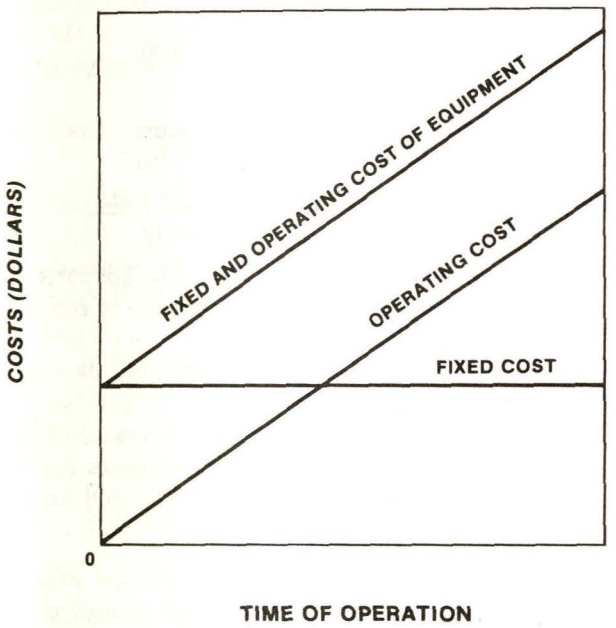


Figure 2.—*Nature of operating costs and fixed cost as a function of hours of operation and use.*

Fuel

The fuel consumption rate of a piece of equipment depends on the engine size, load factor, the condition of equipment, operator's driving habit, environmental conditions, and the basic design of equipment.

Determine the hourly fuel cost by dividing the total fuel cost by the productive time of that equipment.

If total fuel cost is not available, estimate hourly fuel cost (McCraw, 1963) as follows:

Fuel consumption rate for diesel engine:

$$\text{Gallons per hour} = \frac{0.40 \times 0.65}{7.08} \times \text{hp} = 0.037 \times \text{hp}$$

Fuel consumption rate for gasoline engine:

$$\text{Gallons per hour} = \frac{0.46 \times 0.65}{6.01} \times \text{hp} = 0.050 \times \text{hp}$$

Where: .40 = Pounds of diesel fuel consumed per hp hr. (FAO 1976)

.46 = Pounds of gasoline fuel consumed per hp hr. (FAO 1976)

.65 = The ratio of average net horsepower used to net hp available

hp = Net horsepower at rated maximum condition engine speed

7.08 = Weight (pound) of diesel fuel per gallon

6.01 = Weight (pound) of gasoline per gallon.

Then, calculate hourly fuel cost as follows:

For diesel engine:

Hourly fuel cost = 0.037 × hp × cost/gallon (local price)

For gasoline engine:

Hourly fuel cost = 0.050 × hp × cost/gallon (local price)

Example 7.— Suppose that a grapple skidder (diesel engine) has 150 hp and the local price of diesel fuel is $.60 per gallon.

Then,

Hourly fuel cost = 0.037 × 150 × 0.60 = $3.33

Lubricants

These include engine oil, transmission oil, final drive oil, hydraulic oil, grease, and filters. The consumption rate varies with the type of equipment, environmental working condition (temperature) the design of equipment, and the level of maintenance.

Derive hourly lubricant cost by dividing the total lubricant cost by the productive time.

If you lack actual data, estimate lubricant cost per hour (Peurifoy 1975) as follows:

$$Q = \text{hp} \times \frac{0.65 \times 0.006}{7.4} + \frac{c}{t}$$

Where: Q = Consumption rate (gallon/hour) of engine oil

hp = Net horsepower of engine

0.65 = Assume the ratio of average net horsepower used to net horsepower available.

0.006 = Pounds of engine oil consumed between oil changes per horsepower hour.

7.4 = Weight (pounds) of engine oil per gallon

c = Capacity of crank case, gallon

t = Number of hours between oil changes

Then, calculate hourly engine oil cost as follows:

Hourly engine oil cost =
(0.0005 × hp + c/t) × cost/gal. (local price)

Fifty percent of engine oil cost may be used for other lubricants (Peurifoy 1975).

Example 8.— Suppose that a grapple skidder has a 150 hp engine with a crankcase capacity of 5 gallons. The manufacturer recommends changing oil every 90 hours. The local price of oil is $2.00 per gallon. Then,

Hourly engine oil cost =
((0.0005 × 150) + 5/90) × $2.00 = $0.26

Hourly cost of other lubricants =
50% × 0.26 = $0.13.

Thus, the hourly cost of all lubricants for this skidder is the sum of 0.26 + 0.13.

Tires

Some cost analyses include tire cost in the initial investment cost. We consider tire cost part of the operating cost because of their shorter life. This cost is affected by the operator's driving habits, environmental and terrain conditions, wheel alignment, tire maintenance, and the local price.

The hourly tire cost is obtained by dividing the total tire cost (including tire and recaps) and maintenance by the total life of tire and recaps.

Suppose $1,000 for new tires, $500 for recaps, and $400 for tire maintenance and replacement including labor are spent for a rubber-tire skidder in a year. Productive time for skidder is 1340 hours per year. Then,

$$\text{Hourly tire cost} = \frac{1{,}000 + 500 + 400}{1{,}340} = \$1.42$$

If data are not available, the hourly tire cost may be estimated as follows (Jarck 1965):

$$\text{Hourly tire cost} = \frac{1.15\ (\text{tire cost})}{\text{tire life}}$$

Where: 1.15 = 1 + .15 (or 15%) the 15 percent addition to tire cost is for labor to repair or replace a malfunctioning tire.

Tire cost—obtained from manufacturers or local tire dealers.

Tire life—obtained from manufacturers or local tire dealers. One manufacturer suggests 3,000 hours for skidder type equipment and 4,000 hours for feller-bunch type equipment.

Example 9.—Suppose that a contractor selects tires for his rubber-tire grapple skidder and pays $7,000 for four tires. Then,

$$\text{Hourly tires cost} = \frac{1.15\ (7{,}000)}{3.000} = \$2.68$$

LABOR COST

Labor cost is the cost to keep an operator on the job; it may be on an hourly basis, a per unit of output basis,[6] or a combination of both. An employer must also contribute to Social Security, Federal Unemployment Insurance, State Unemployment Insurance, Workmen's Compensation, and other programs.

Social Security

This provides benefits for retirement, survivors, disability, and hospital insurance. For 1978, an employee pays 6.05 (6.13)[7] percent of the first $17,700 ($22,900) of his annual gross earnings and an employer matches this amount (U.S. Department of Treasury, IRS 1978). More information can be obtained from the Internal Revenue Service Office.

Federal Unemployment Insurance

Under law, an employer is subject to contribute if he employs one or more persons for any part of a day during each of 20 different calendar weeks or pays wages of $1,500 or more in any calendar quarter. For 1978, the rate is 3.4 percent on the first $6,000 of wages paid to each employee during the calendar year. A credit of 2.7 percent is given for contribution to State Unemployment Insurance and can be subtracted from the base federal rate of 3.4 percent (U.S. Department of Treasury, IRS 1978).

State Unemployment Insurance

The rates vary from State to State. The range is from 1.4 percent (Mississippi) to 2.8 percent (Maine) (APA 1977). More information can be obtained from the State Employment Security Agency and the State Insurance Commission.

Workmen's Compensation

Workmen's compensation provides protection for an employee against occupational hazards and benefits for his family to offset diminishing income resulting from injury on the job and work-related illness. The rate of workmen's compensation and benefits for employees vary from state to state. In

logging or lumbering (transportation of logs to mill, construction, operation, logging railroads, or driving), the rates ranged from $10.20 per hundred dollars of payroll (North Carolina) to $55.52 per hundred dollars of payroll (Kentucky) (Hensel 1977). The Employers Insurance of Wausau, the State Employment Security Agency and the State Insurance Commission can provide more information.

Others

Other employer contributions may include paid vacation, paid holidays, paid sick leave, health insurance, uniforms, safety equipment, etc. The items and the rates vary greatly with locality and employers.

Labor cost is generally considered an operating cost. However, most operators stay in the woods and do minor repairs when the machines are down. Most of the time the wages are paid on a scheduled operating time basis. In this paper, labor cost is calculated on the scheduled operating time and is separated from fixed and operating cost. In this way, we can separate the cost of the machine itself from labor cost which varies greatly with locality and employers.

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[6]*The employer must pay minimum wages, even on per unit of output.*

[7]*Figures in parentheses are for 1979, based on personal contact with Internal Revenue Service personnel.*

ESTIMATING TOTAL EQUIPMENT COST

Two examples of estimating costs for logging follow. (A sample work sheet for calculating total equipment cost per unit of time is presented in Appendix B.)

Example 10.— A logger buys a shortwood front end loader costing $40,000 (F.O.B. delivered price). What are the hourly equipment costs? Assume the following:

Preliminary Data and Determinations

- Description of equipment—diesel, 80 hp net, 4 gallons of crankcase capacity, 80 hours between oil changes, track type.
- Diesel fuel, $.60/gallon.
- Engine oil, $2.00/gallon.
- Interest rate 12%, insurance 3%, taxes 3%.
- Labor cost, $7.00/hour (include the employer's contribution), based on scheduled operating time.
- Initial investment cost (P) $40,000
- Salvage value (S) (20% of P) $8,000
- Economic life (N) 5 years
- Scheduled operating time (SH) 2,000 hr/yr (8 hrs./day, 250 working days)
- Utilization (see tabulation, page 3) 65%
- Productive time (H) (2,000 × 65%) 1,300 hr/yr

Fixed cost

- Depreciation (D) $= \frac{P-S}{N} = \frac{40{,}000-8{,}000}{5 \text{ yrs}}$ = $ 6,400/yr
- Interest, insurance, and taxes 18% × AVI[8] = $ 4,896/year

(1) Fixed cost/year = $11,296.00

(2) Fixed cost/H = $ 8.69

Operating Cost (based on productive time)

Maintenance and repair:
(100% (see tabulation, page 8) × D) ÷ 1,300 = $ 4.92

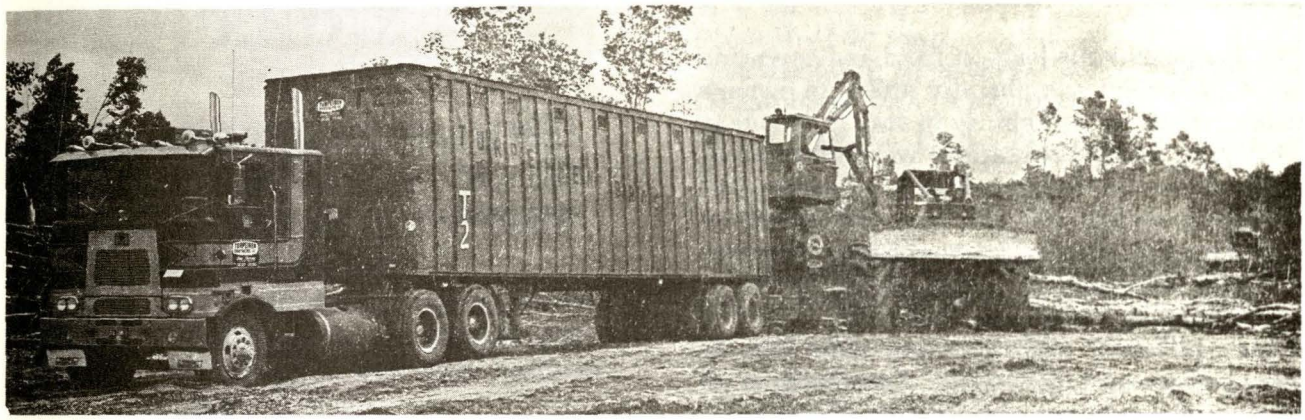
- Fuel: (0.037 × 80 × .60) $ 1.78
- Lubricants:
  Engine oil ((.0005 × 80) + (4/80)) × $2.00 = $.18
  Other lubricants (50% of engine oil) = $.09
  $.27

(3) Operating Cost per Productive Time = $ 6.97

Fixed and Operating Equipment Costs per Productive Time (excluding labor cost)
Fixed cost/H ($8.69) + Operating cost/H ($6.97) = $15.66

Labor Cost per Productive Time
($7.00/SH × $\frac{2000 \text{ SH}}{1300\text{H}}$)[9] = $10.77

Fixed and Operating Equipment Costs per Productive Time with Labor Cost = $26.43



Example 11.— A contractor wishes to estimate the fixed and operating cost of a rubber-tired skidder costing $45,000 (F.O.B. factory price).

Preliminary Data and Determinations

- Description of equipment—diesel, 115 hp, 10 gallons of crankcase capacity, 120 hours between oil changes.
- Diesel fuel, $.60/gallon.
- Engine oil, $2.00/gallon.
- Interest 12%, insurance 3%, taxes 3%.
- Labor cost $7.00/hour (including the employer's contribution)
- Initial investment (P):

Purchase cost (without a grapple)	$45,000
Extra attachment cost (grapple)	$ 6,000
Sales taxes (4%)	$ 2,040
Freight cost (5 cents per pound) (shipping weight 15,000 lbs. × .05)	$ 750
Less tires cost	$-7,000
P =	$46,790

- Salvage value (S) (20% of P) $ 9,358
- Economic life (N) 3 yrs
- Scheduled operating time (SH) 2,000 hr/yr
- Utilization (see tabulation, page 3) 67%
- Productive time (2,000 × 67%)(H) 1,340 hr/yr.

Fixed Cost

- Depreciation (D) = (P−S)/N = ($46,790 − $9,358)/3 yr = $12,477.33/yr.
- Interest, insurance, and taxes (18% × AVI)[10] = .18 × $34,312.67 = $ 6,176.28/yr.

(1) Fixed cost per year = $18,653.61

(2) Fixed cost per Productive Time = $ 13.92

Operating Cost (based on productive time)

- Maintenance and repair: (60% (see tabulation, page 8) × D)/1,300 = $ 5.59
- Fuel: (0.037 × 115 hp × .60) = $ 2.55
- Lubricants:
  - Engine oil ((.0005 × 115) + (10/120)) × $2.00 = $ .28
  - Other lubricants (50% of engine oil) .14
  - = $ .42
- Tire ($7,000 × 1.15)/3,000 = $ 2.68

(3) Operating Cost Per Productive Time = $ 11.24

Fixed Operating Cost per Productive Time (excluding labor cost)

(2) + (3) = $13.92 + $11.24 = $25.16

Labor Cost per Productive Time

$7.00/SH × (2,000 SH/1,340 H) = $10.45

Fixed and Operating Cost of Equipment per Productive Time With Labor Cost = $35.61

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[8]*Average value of yearly investment (AVI)*

$$AVI = \frac{(P-S)(N+1)}{2N} + S = \frac{(40{,}000-8{,}000)(5+1)}{2(5)} + 8{,}000 = 27{,}270/yr.$$

[9]*$7.00/SH is based on the scheduled operating time. Operating cost in this example is based on productive time. Thus, multiplying $7.00/SH by 2000/1300, we can obtain the labor cost per productive time (H).*

[10]$$AVI = \frac{(P-S)(N+1)}{2N} + S = \frac{(46{,}790-9{,}358)(3+1)}{2(3)} + 9{,}358 = 34{,}312.67$$

RECOMMENDATION

Analyses and knowledge of fixed and operating cost of equipment significantly affect an owner's economic position and ability to stay in business. In the past, logging operations were incurred by low fixed cost (i.e., low investment on equipment) and high operating cost (i.e., high dependency on labor). Rapid mechanization has greatly increased fixed costs. Most logging is now capital intensive. This requires a continuous awareness of how to reduce equipment and operating costs and increase equipment productivity. Knowledge of all elements of equipment cost and how to determine them are paramount to successful logging.

To estimate cost of new equipment for which cost data are unavailable, industry data, manufacturer's guides or rules of thumb may be used initially. These estimates can later be refined as the owner's own cost data become available. There are so many variations in interest, insurance, taxes, fuel, lubricant, labor cost, etc., from one type of equipment to another and from one locality to another that no standard cost can be applied for estimating individual equipment cost. However, the owner can keep accurate cost data as a basis for estimation. These should be recorded daily by the operator, and reviewed by the logging supervisor, owner, or contractor at least weekly. Once the cost of equipment has been established with relative precision, it can be used as a standard. It can also provide an effective guide for improving the efficiency of logging operations and estimating production costs or logging operation cost.

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APPENDIX A

THE THEORY AND FORMULATION OF THE AVERAGE VALUE OF YEARLY INVESTMENT COST

Here we summarize the concept and theory for the average value of yearly investment cost ($AVI = \frac{(P-S)(N+1)}{2N} + S$), and give reasons why this mathematical formula is usable only with the straight line method to calculate the depreciation.

Arithmetic Progression

An arithmetic progression is a sequence of numbers for which there is a constant d (the common difference) such that the difference between any two successive terms is equal to d (Lapedes, 1976).

The sequence 1, 3, 5, 7, 9 is an arithmetic progression having 5 terms, the first term is 1 and the common difference is +2. The sequence 9, 7, 5, 3, 1 is an arithmetic progression having 5 terms, the first term is 9 and the common differnce is −2.

If the first term and the common difference are given, the Nth term is obtained from the following formula:

$$PN = P1 + (N-1)\,d \qquad (1)$$

Where:

PN = the Nth term
P1= the first term
d= the common difference.

To illustrate this equation, consider the preceding sequence (9, 7, 5, 3, 1).

The first term is 9 and the common difference is −2. Then, the 3rd and 4th terms can be obtained as follows:

$P3 = 9 + (3-1)(-2) = 9 - 4 = 5$
$P4 = 9 + (4-1)(-2) = 9 - 6 = 3$

We can find the sum of the first N terms of an arithmetic progression by using the following formula:

$$SN = \frac{N}{2}(P1 + PN) \qquad (2)$$

Where:
SN = the sum of the first + N terms
PI = the first term
PN = the Nth term

Substituting equation (1) for (2), the equation (2) can be written as follows:

$$SN = \frac{N}{2}(P1 + P1 + (N-1)\,d)$$
$$= \frac{N}{2}(2P1 + (N-1)\,d) \qquad (3)$$

If, as an example, we want to find the sum of the first 3 terms in sequence (9, 7, 5, 3, 1), then:

$$S3 = \frac{3}{2}(2(9) + (3-1)(-2))$$
$$= \frac{3}{2}(18-4)$$
$$= \frac{3}{2}(14)$$
$$= 21$$

The sum of the first 5 terms is:

$$S5 = \frac{5}{2}(2(9) + (5-1)(-2))$$
$$= \frac{5}{2}(18-8) = \frac{5}{2}(10)$$
$$= 25$$

Average value of yearly investment (AVI):

The tabulation for straight line method (page 4) can be written as follows:

$85,000; $71,400; $57,800; $44,200; $30,600; $17,000

This is a sequence and an arithmetic progression having 6 terms, the first term is $85,000 and the common difference is −13,600. It means we can use the equation (1) and (2) or (3) to find Nth term and the sum of the first Nth term. Here, the common difference of $13,600 is obtained by using the straight-line method; depreciation = $\frac{P-S}{N}$.

Thus, the equation (3) can be rewritten by substituting $-\frac{(P-S)}{N}$ for d and P for P1.

$$SN = \frac{N}{2}(2P + (N-1)(-(\frac{P-S}{N})))$$
$$= \frac{N}{2}(2P + \frac{P-PN-S+SN}{N})$$
$$= \frac{N}{2}(\frac{2PN-PN+P-S+SN}{N})$$
$$= \frac{PN+SN+P-S}{2}$$
$$= \frac{PN-SN+P-S+2SN}{2}$$
$$= \frac{P(N+1)-S(N+1)+2SN}{2}$$

Dividing this equation (the sum of the first N term) by Nth term, we can obtain the average value of this sequence (i.e. average value of yearly investment).

Average value of this sequence is:

$$\left[\frac{P(N+1) - S(N+1)+2SN}{2}\right] \div N$$

$$= \frac{P(N+1)-S(N+1)+2SN}{2N}$$

$$= \frac{(P-S)(N+1)}{2N} + \frac{2SN}{2N}$$

$$= \frac{(P-S)(N+1)}{2N} + S = AVI$$

Thus, the mathematical formula of AVI is based on the common difference (P−S)/N. For this reason, it can be used only as a straight-line method to calculate the depreciation.

The mathematical formula can be simplified, if salvage value is not to be taken into account, by substituting zero for S in this formula.

$$\text{AVI (no salvage value)} = \frac{(P-O)(N+1)}{2N} + 0$$

$$= \frac{P(N+1)}{2N}$$

APPENDIX B

Machine Cost

Description and Data:

Manufacturer: _____ Model: _____ HP: _____

Purchase price (f.o.b. delivered): $ _____

Less: tire cost _____

INITIAL INVESTMENT (P) $ _____

Salvage Value (S)(__ % of P) $ _____

Estimated Life (N) _____ years

Scheduled operating time (SH) _____ hrs/yr

Utilization (U) _____ %

Productive time (H) _____ hrs/yr

Average value of yearly investment (AVI)

AVI = [((P−S)(N+1))/2N]+S $ _____/yr.

I. **Fixed Cost:**

Depreciation = (P−S)/N

Interest (__%), Insurance (__%), Taxes (__%) = $ _____/yr.

Total__% × ($____/yr)

AVI = $ _____/yr.

(1) Fixed cost per year

(2) Fixed cost per H (1 ÷ H) $ _____

II. **Operating Cost:** (based on productive time) $ _____

Maintenance and repair (__ % × ((P−S)/(N×H))

Fuel (____ gph × $____/gallon) $ _____

Oil & lubricants $ _____

Tires (1.15 × (tire cost)/tire life in hrs.) $ _____

(3) Operating Cost per H $ _____

III. **Machine Cost per H** *(without labor)* (2+3) $ _____

IV. **Labor Cost** *($* ____/hr ÷ U) $ _____

V. **Machine Cost per productive hr. with labor** (III. + IV) $ _____

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Put trash in the proper place.